4. WATER CONSERVATION AND REUSE

4.1 Determining the Nature of the Problems

Before an effective water and wastewater management plan can be designed, tourist facility providers must conduct an audit to determine the type and amount of wastewater being generated and to assess water use, reuse and treatment practices being followed.

Issues that should be addressed to help identify problems include:

- Assess current wastewater treatment practice before water is discharged whether to:
  - On-site treatment facility
  - Municipal treatment facility
- Identification of where wastewater is generated within a tourism facility
- Determine whether discharged wastewater quality meets effluent standards (if they exist)
- Identify whether on-site wastewater treatment is used for non-potable applications (if applicable)
- Assess complaints from customers and residents about reclaimed wastewater quality, e.g. kind and nature of odors or other suspended impurities

Once the situation has been assessed, a range of approaches and techniques to deal with wastewater can be considered. This work must be done by a water quality and wastewater engineer.

4.2 Conservation of Water

The more water used by a facility the more wastewater is generated. Optimizing water consumption can help minimizing wastewater and also reduce the energy required to treat the water. The following is a list of questions on water usage that a facility should consider in order to be able to develop priority areas of actions in dealing with water use conservation.

- Have any water saving practices been taken for the last twelve months?
- Is water use monitored?
- Is the water system regularly checked for leaks or surges in consumption?
- Are staff encouraged to save water?
- Are guests encouraged to save water?
- Does the tourism facilities have any water intensive activities e.g. swimming pool, garden and laundry services?
- Have the water efficiency equipment been used?

There are two major ways to minimize water consumption in most facilities.

- Reducing water loss:
  Overall water consumption can be reduced by following good water management practices by regularly repairing equipment, fixing leaky taps, turning off equipment when not in use and replacing faulty/old equipment. To facilitate these tasks, leak detection instrumentation is commercially available. The flow rates of conventional faucets vary from 10-15 liters per minute. A leaky faucet, dripping one drop per second, can waste 135 liters of water daily. Flow

valves can be adjusted on faucets and should be checked regularly for leaks. Aerators can be screwed to the faucet head to reduce water consumption and increase the amount of air in the water flow.

- Installation of water efficiency equipment:
  Facility managers should consider installing commercially available devices such as ultra low flush toilets, spray nozzles, urinals, faucet aerators and low flow showerheads to reduce overall water consumption. Other water-saving faucet devices include infrared and ultrasonic sensors, water spigots and pressure-reducing valves. Although they are expensive, they can save a great deal of water.

Within each area of the facilities there are a number of practices that can reduce the amount of water used in operations.

Kitchen and Food Preparation

Dishwashing is a major water-consuming/wastewater generating activity. Water use and discharge can be reduced by: educating staff to hand-scrape plates before loading, filling each rack to maximum capacity, recycling final rinse water and keeping flow rates as low as possible.

Guestrooms

Installing proper devices and encouraging guests to conserve water will reduce consumption and discharge.

Toilets

Water use and the amount of wastewater discharge can be reduced by making improvements to toilets/flush mechanisms. There are three major types of toilets and one modified system:

- Gravity flush toilets are the most common types with water efficiency options including improved maintenance and retrofitting.

- Flush valve toilets use water line pressure to flush water into the sanitary sewage system. Valves can be inserted to reduce flush volumes by 2-4 liters per flush and units replaced with ultra low (6 liters per flush) flush valve mechanisms to maximize water savings.

- Pressurized tank system toilets are the most modern and efficiently designed toilets currently available but are expensive to install.

- The lid system is a completely passive water conservation system that attaches itself to the top of the toilet tank - after flushing, users wash their hands with clean water which drains into the tank below by diverting water before it enters the holding tank, water is used twice. For additional information on this system please see http://www.greenculture.com/pr/ws.html#cp.

Showerheads

Showerhead replacement and modification is an effective way to conserve water. Most conventional showerheads use 11-25 liters of water per minute at a standard water pressure rate of 60 psi. However, new standards require showerheads to use a flow of

no more than 9.5 liters per minute. Showerheads should be checked regularly for leaks; flow restrictors and temporary cut-off valves can be installed to lessen water use and reduce the amount of wastewater treated by a facility. In addition guests and staff can be encouraged to take shorter showers.

Laundry

Washing machines should be filled to capacity to reduce the number of loads thereby saving water. When machines are not full, settings should be adjusted to lower water level. Installing a water filter to remove impurities can optimize machine performance. Recycling rinse water for the next pre-wash cycle is recommended, if space is available for storing the water in a small tank.

For additional information on products/ technologies in your region:
http://www.greenculture.com

Case Study: Forte Hotels - Jumeria Beach, Dubai, UAE

The ozone washing system installed at the Forte Grand Jumeria Beach in 1996 has produced several environmental benefits. Ozone in the system is used as detergent thus eliminating the need for chemicals. Energy requirements are reduced because the system uses cold water, which is filtered and recycled, drastically reducing the volume of wastewater produced. The payback period was about 16 months.

Additional information: Mr. Janaka Wijayawardhana (Chief Engineer),
E-mail: engin@lemeridien-jumeria.com

4.3 Reusing Wastewater

Wastewater can be a valuable resource for tourism facilities. The reuse of wastewater can ease the demand on limited fresh water supplies and improve the quality of streams and lakes by reducing discharged effluent. Wastewater may be reclaimed and reused for crop and landscape irrigation, groundwater aquifer recharge or recreational purposes. Water reclamation for drinking is technically possible but this reuse is not particularly appealing to the public. Normally reused water can be employed for non-potable purposes, e.g. flushing toilets and urinals. Reused water or gray water can be marked with a blue dye to ensure it is not used for potable purposes, e.g. drinking, showering or washing.

Case Study: Minneapolis City Center Marriot Hotel - Minnesota, USA

The 538-room Minneapolis City Center Marriot Hotel, Minnesota inaugurated laundry gray water and cold water reuse systems. The gray water reuse system obtains the last rinse water from one wash load, filters and transfers it to a holding tank where it is heated to 140^{0}F using a steam heat exchanger. The gray water is then used as first wash water for the next wash load.

The cold water reuse system obtains water from the discharge of water-cooled condensers, water-cooled heat pumps and heat exchanger on the dry cleaning machine. The water is held in a cold water storage tank and used as a cold water supply for the washing machines. Both these systems allow water to be used twice before being discharged.

Additional information: Ms. Barabara Brodell, E-mail: barbara.brodell@mariott.com

Reuse takes place when water or wastewater is used again in a facility before discharge into a treatment system (Figure 8). Reclamation is the process of treating wastewater to achieve a certain quality of water which can be reused. These commonly adopted water conservation techniques require technical skill and expertise; the technology is universally available and widely accepted.

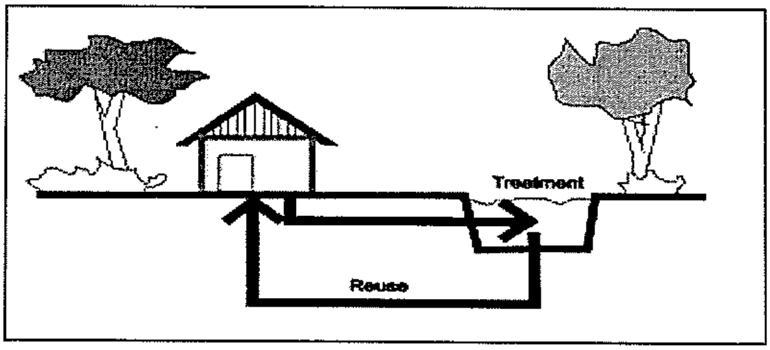

Figure 8: Wastewater Reuse within a Tourist Facility

An important step in successful wastewater reclamation and reuse is source separation. Wastewater, generated from various sources, has different characteristics and potential reuse capabilities and should be separated into different streams with separate collection tanks for each source of wastewater generated. Wastewater can be separated in the following ways:

- Wastewater from bathrooms, sinks and kitchens has less toxicity, good reuse potential, requires minimal treatment and can be separated into one stream.
- Wastewater from toilets and laundries contains more toxicity, requires treatment prior to reuse and can be separated as another stream.

In an existing facility this kind of separation is difficult and requires major plumbing and structural retrofitting. When designing a new facility this type of separation can be seen as cost effective.

There are several wastewater reclamation processes and techniques that can be employed and which are displayed in Table 3 (adapted from Metcalf and Eddy (1991) "Wastewater Engineering Treatment, Disposal and Reuse"; McGraw-Hill International Ed., New York).

Solid/Liquid Separation

Process	Applications
o Sedimentation	Removal of particles from wastewater larger than 30 μm. – typically used as a primary treatment approach
o Filtration	Removal of particles from wastewater larger than 3 μm. - typically used downstream of sedimentation (conventional treatment) or following coagulation/flocculation
o Oil and grease removal	Removal of oil and grease from wastewater - flotation process may also be used

Biological Treatment

Process	Applications
o Aerobic treatment	Removal of dissolved and suspended organic matter from wastewater
o Oxidation pond	Reduction of suspended solids, BOD, pathogenic bacteria and ammonia from wastewater
o Nutrient removal	Reduction of nutrient content of reclaimed wastewater
o Disinfection	Protection of public health by removal of pathogenic organisms

Advanced Treatment

Process	Applications
o Activated carbon	Removal of organic compounds
o Air stripping	Removal of ammonia nitrogen and some volatile organics from wastewater

Chemical Coagulation and Precipitation

Process	Applications
o Lime treatment	Use of lime to precipitate cations and metals from solution
o Membrane filtration	Removal of colloids and micro-suspended impurities
o Reverse osmosis	Removal of dissolved salts and minerals from water - also effective for pathogen removal

Table 3: Unit Processes and Operations in Wastewater Reclamation

Establishing Wastewater Reuse Program

In order to establish a wastewater reuse program at a facility the following actions should be followed.

- Identify the need for wastewater reuse by thinking about these questions.
  - Is sufficient wastewater being produced to be economically reused?
  - Is the availability of freshwater a major concern? It can be a problem at facilities on islands and remote areas where wastewater reuse could augment freshwater and groundwater resources.
  - Is there a reuse potential for treated wastewater? Do non-potable reuse options such as gardening and landscaping exist?
  - Does the present wastewater treatment infrastructure require major retrofitting to install a reclamation scheme?
  - Is the retrofitting economically feasible?

- Given the technical nature of wastewater reuse a wastewater engineer or water conservation and reuse expert should be hired to:
    - Identify conveyance and storage requirements for wastewater reclamation and reuse.
    - Assess existing treatment infrastructure and the amount of retrofit required to install a wastewater reclamation system.
    - Estimate the cost of retrofitting, installation, operation and maintenance by using cost benefit analysis in order to assess the payback period.

- Identify the treatment required to implement the reuse options. Geographic, climatic and economic factors dictate the appropriate degree and form of wastewater reclamation.

- Check local reuse standards. In many developing countries where standards are unavailable, World Health Organization (WHO) guidelines for microbial and viral removal requirements can be used. Potential health risks associated with wastewater reclamation and reuse relate to the extent of direct exposure to reclaimed water and the adequacy, effectiveness and reliability of the treatment system. Protection of human health should be a major consideration in a wastewater reuse program.

Case Study: The Cities of Calvia and Rimini

The city of Calvia in the Balearic Islands in Spain, and the Italian balneary of Rimini on the Adriatic Sea are both located in the Mediterranean biodiversity conservation hotspot, and heavily dependent on tourism. Both experienced over-development in tourism facilities and environmental degradation in the 80s, but faced the challenge with often radical measures. In the case of Calvia, a Local Agenda 21 process managed by the municipality led to closing and even implosion of hotels, expansion of sewage systems, landscape renovation and creation of additional protected areas. The establishment of an environmental levy on hotel room sales in 2001, with extensive public awareness and marketing campaigns, provided important resources for environmental management – in spite of significant resistance from tour operators and tourists.

In Rimini, effluents with high organic content and coastal eutrophization from fertilizers led to algal blooms and heavy fish mortality in 1985, with ensuing odors and visible pollution causing occupancy rates to fall around 25%. The tourism industry then led local authorities to engage agribusinesses to reduce use of fertilizer and hotels to improve wastewater management. Regular monitoring guaranteed compliance with stricter regulations. Awareness and marketing campaigns gradually led to image improvement and the tourism flows were re-established by the end of the decade. The image of both destinations today is associated with their leading efforts towards sustainable tourism (UNEP, Tourism and Local Agenda 21, 2003)

Case Study: Club Med Lindeman Island, Queensland, Australia

Club Med Lindeman Island took the entire environmental process to heart when they decided to build the resort because of its World Heritage location. The Great Barrier Reef Marine Park Authority considers Lindeman as a benchmark in how a resort can care for an island and its delicate environment. All waste is sorted and treated and transported from the island. The resort's wastewater is treated and used to irrigate the island's nine hole golf course which is fertilized with the waste sludge – dried, mulched and mixed with grass clipping. And when the island's original course was expanded Club Med only used areas of land which were already degraded by previous pastoral use.

The resort's dam and the wastewater holding pond have had a very positive effect on the island's wildlife by providing a habitat for birds such as the Eastern Swamp Hens, Black Ducks and a number of migratory species. Extensive planting of native flora around the resort has increased food supplies for the birds.

Additional information: Queensland Ecotourism at
http://www.qttc.com.au/ecotourism/home.asp

5. WASTEWATER TREATMENT SYSTEMS

The primary objective of wastewater treatment systems is to protect the natural environment and public health. Potential pollutants need to be eliminated from wastewater before it can be safely disposed/reused. Zero discharge of wastewater is technically possible but very costly. The bulk of wastewater remains to be disposed of after the treatment processes have been completed. Wastewater can be disposed of in a municipal system or on-site (if conditions are appropriate). In urban areas, where land availability is an issue in setting up treatment system, most facilities are committed to the municipal treatment system. While in remote areas such as mountains and island locations, where no centralized system exists, on-site wastewater treatment systems are required. This section will look at different types of on-site wastewater treatment systems, which can range from simple septic tanks to tertiary level treatment systems for wastewater reclamation and reuse, and to using natural features, either land-based or water-based, to treat wastewater before disposing to natural receptors e.g. surface water and groundwater bodies or land surfaces.

5.1 Engineered Wastewater Treatment System

Engineered systems mimic the natural systems of water purification. Engineering principles are applied to the separation of pollutants from wastewater. They can be operated either as centralized or on-site wastewater systems. On-site wastewater treatment systems are used primarily in facilities in remote locations as illustrated in Figure 9. The selection of these types of treatment processes can be restricted by:

- Discharge limits
- High capital costs of treatment plants
- Limited operation and maintenance capabilities

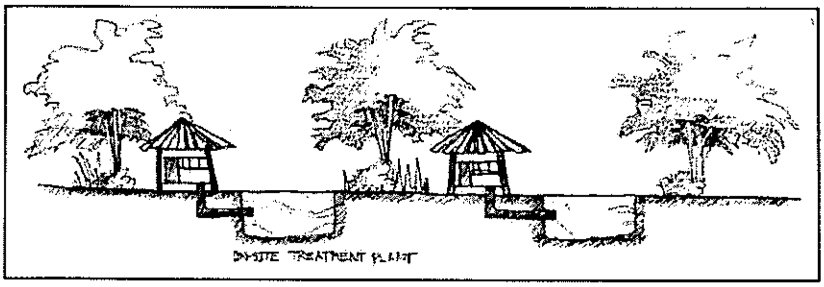

Figure 9: On-Site Wastewater Treatment Systems

A variety of treatment systems can be used but a common treatment system consists of a septic tank for partial treatment and a subsurface soil disposal field for final effluent disposal. In cases of land scarcity, conventional disposal fields can be replaced by re-circulating granular media filters.

Septic tanks are prefabricated tanks that serve as combined settling and skimming tanks and an anaerobic digester. Most septic tanks are made of concrete or fiberglass and should be watertight and leak-proof to ensure proper wastewater treatment.

Operationally, effluent flows into the vault through inlet holes in the center of the vault chamber. Before entering the vault chamber, effluent usually passes through a screen on the inside of the vault. The screen must be removed and cleaned periodically to avoid clogging. Solids from the incoming wastewater settle and form a sludge layer at the bottom of the tank. Grease and other light materials float on the surface where a scum layer is formed where floating material accumulates. Settled and skimmed wastewater flows from the clear space between the scum and sludge layers for additional treatment and/or disposal. The organic matter retained at the bottom undergoes anaerobic digestion and converts to gases such as carbon dioxide, methane and hydrogen sulphide. The digested bottom layers, along with accumulated solids, effectively reduce the volume of the tank and need to be pumped periodically. Figure 10 illustrates a typical septic tank and soaking pit system.

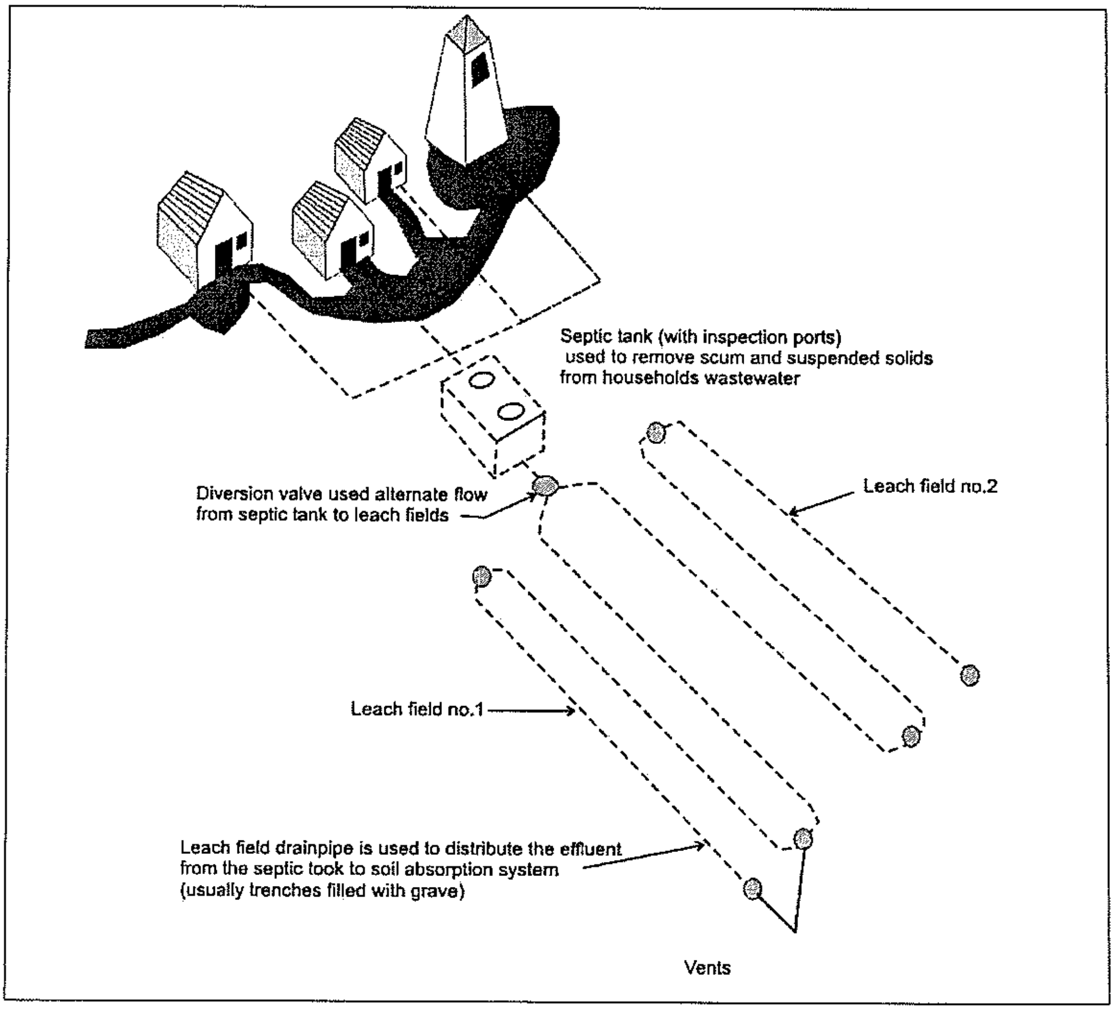

Figure 10: Septic Tank Soaking Pit System

Case Study: Perkin Lenca Hotel – Province of Morazan, El Salvador

The owners (a US-Salvadoran partnership) of the largest hotel in El Salvador's remote, North-Eastern Morazan Province, were looking for an appropriate environmental-friendly solution to treat their wastewater in a relatively small area. After extensive research they decided to implement two independent systems each consisting of a two-chambered septic tank ($24m^2$) for the separation of solids, with the overflow running through a line of five tanks. The tanks are filled with gravel and planted with a variety of local water species found in the surrounding ravines and gullies. The water from each system is used to irrigate a variety of trees. During normal and low use periods, the plants in the bottom two tanks require external watering, given the excessive consumption of the plants in the first three tanks. The system is designed to expand from the present seven cabins, plus other facilities to twenty-one cabins. Maintenance consists of a once-a-month introduction of natural enzymes, the cutting-back of mature plants, and a loosening of the root-mass every sixty days. After four years of implementation, there is no sediment build-up in the system and the only adjustment has been to separate the grey water from the kitchen (which does carry grease) through a separate filter.

Additional information: Ronald Brenneman, E-mail: info@perkinlenca.com, http://www.perkinlenca.com

5.1.1 Levels of Wastewater Treatment

Wastewater can be treated by physical, biological or chemical processes. There are four levels of wastewater treatment: preliminary, primary, secondary and tertiary as illustrated in Figure 11.

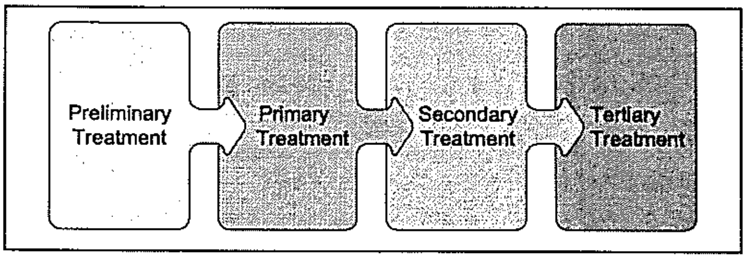

Figure 11: Levels of Wastewater Treatment

Preliminary and primary treatment methods remove about 60% of total suspended solids and 35% of biochemical oxygen demand (BOD).

A number of different methods of analysis have been developed to determine the organic content of wastewater. Laboratory methods commonly used to measure gross amounts of organic matter in wastewater (typically greater than 1 mg/L) include biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total organic carbon (TOC) (Metcalf and Eddy, 1991).

The most widely used parameter of organic pollution in both wastewater and surface water is the 5-day Biochemical Oxygen Demand (BOD_5). This determination involves the measurement of dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. The BOD_5 test results are used (Metcalf and Eddy, 1991):

- To determine the approximate quantity of oxygen that is required to biologically stabilize the organic matter.
- To determine the size of wastewater treatment facilities.
- To measure the efficiency of different treatment processes.
- To determine compliance with wastewater discharge permits.

Secondary treatment removes more than 85% of suspended solids and BOD. These treatment levels do not remove dissolved inorganic. When more than 85% of total solids and BOD must be removed, or when nitrogen and phosphorous concentrations must be reduced, tertiary treatment methods are used.

Tertiary processes can remove more than 99% of all impurities from wastewater, producing water quality almost up to drinking standards. Tertiary treatment can be expensive (often double the cost of secondary treatment) and is used only under special circumstances.

Most countries have national and regional discharge limits for the disposal of effluents. The type of wastewater treatment method used generally depends on the size of a tourist facility. For example, a small roadside cafeteria or bed & breakfast facility will probably not have effluent treatment; a larger establishment will have at least a septic tank to treat wastewater prior to disposal. Location is another factor especially in remote areas where there are seldom any municipal standards or enforcement of disposal standards.

5.1.2 Preliminary Treatment

Preliminary wastewater treatment is defined as the removal of wastewater constituents that may cause maintenance or operational problems during treatment. Floating objects, e.g. driftwood, rags and plastic, and coarse suspended matter such as grit, need to be removed. Screens are common applications in most treatment facilities. At tourist facilities, things like tissue paper or plastic bags must be eliminated before they reach the wastewater stream. Oil and grease removal applications are also common in tourist facilities. Grit removal can be used as part of wastewater treatment.

<u>Screening and Comminuting</u>

Screening and comminuting is used for the removal of debris such as rags and floating objects where screens provide a physical barrier to the flow of wastewater and block unwanted materials. Screens, classified as coarse, medium and fine, are available in bars, racks or rotating drums. Comminution grinds the screened material into a pulp before it flows into the wastewater stream.

<u>Grit removal</u>

For removal of coarse suspended material such as sand, broken glass, silt and pebbles which may wear down or clog pumps and other mechanical devices, a settling chamber is provided where grit settles. Aerated grit chambers use the shearing action of air bubbles provided by air diffusers to strip the inert grit of much of the organic material adhering to the surface, assisting the settling of grit particles.

<u>Flotation process</u>

To remove large quantities of oil and grease, compressed air is forced into the wastewater from below. This encourages non-soluble oil and grease to float to the surface and to be skimmed off.

5.1.3 Primary Treatment

In primary treatment, a portion of suspended solids and organic matter is removed from wastewater. This removal takes place by physical methods such as sedimentation or settling. Settleable solids must be removed to decrease the load on further treatment processes. Usually the process is carried out in settling basins where quiescent conditions are provided to wastewater to encourage settling of solids. Sedimentation can be enhanced by adding chemicals such as alum which assists floc formation. This process is called coagulation and flocculation. The settled solids, known as sludge, need to be periodically drained and disposed of in a proper manner, either in municipal landfills or other recommended sites. Sedimentation can also be enhanced by using physical structures, e.g. tubes and plates, to accelerate settling.

5.1.4 Secondary Treatment or Biological Treatment Process

Secondary treatment is directed primarily at removing biodegradable organics and suspended solids. Biological processes are used to convert finely divided, dissolved organic matter in wastewater into inorganic carbon dioxide gas (escapes in the atmosphere) and settleable biological and organic solids (eliminated in sedimentation tanks). There are two types of biological processes – aerobic and anaerobic.

<u>Aerobic Processes</u>

Two main types occur in the presence of oxygen:

- Suspended growth processes are when the microorganisms responsible for the conversion of organic matter are in a state of suspension. An activated sludge process is the most common type of suspended growth aerobic process. Wastewater is treated in a tank where the microbial population is maintained in suspension by constant agitation. Aeration is provided by mechanical surface aerators or diffused air using aerators placed at the bottom of the reaction tank. The soluble organic content is converted to carbon dioxide which escapes as gas and solids which separated from wastewater in a secondary settling tank placed downstream from the aeration tank.

- Aerobic attached growth processes are usually used to remove organic matter in wastewater and to achieve nitrification, e.g. trickling filters and rotating biological contractors.

  - Trickling filter

  A trickling filter consists of a bed of coarse material to which microorganisms are attached and through which wastewater is percolated. The filter media consists of rock (rock size – 85-100 mm, rock layer depth – 1-3 m) or a variety of plastic packing materials. Trickling filters are usually circular; wastewater is distributed over the top of the bed by a rotatory distributor.

  - Rotating biological contractors (RBC's)

  The RBC process consists of a series of closely-placed disks (3-3.5 m in diameter) mounted on a horizontal shaft and about 40% of the surface area is immersed in wastewater. The disk rotation is generally between 1.5-2 rpm. As the disks rotate, they alternatively absorb oxygen from the air and organics from wastewater. RBCs are designed to operate in stages and can achieve secondary effluent quality standard or better. By increasing the number of stages, it is possible to achieve nitrification along with removal of organics.

Anaerobic Processes
This process carried out in the absence of air is used to treat high strength wastewater. There are two types – attached growth and suspended growth. The most commonly used is a wholly mixed anaerobic suspended growth process called anaerobic digestion process. The high strength organic material is converted biologically, under anaerobic conditions, into a variety of end products including methane and carbon dioxide. The slow process, carried out in an airtight reactor, has a high retention time in a reaction tank. This is a delicate process where optimum conditions of alkalinity, pH, Volatile Fatty Acids (VFA) and temperature must be maintained for microorganisms to grow properly.

5.1.5 Tertiary Treatment or Advanced Wastewater Treatment Process

In many areas of the world, wastewater discharge quality criteria (or effluent) are becoming stricter. In addition to organic matter and suspended solids, permit requirements may include removal of nutrients, e.g. ammonia, nitrates and phosphates, specific toxic compounds, e.g. metals (mercury and arsenic) or volatile organic compounds (VOC's) in pesticides and other harmful chemicals. Tertiary wastewater treatment is required to achieve removal of nutrients. With the need to reuse wastewater, advanced treatment must be provided at tourist facilities.

Removal of nitrogen and its compounds
Nitrogen in wastewater is usually found in the form of ammonia and organic nitrogen (urea and amino acids). Removal of nitrogen can be accomplished biologically or chemically. Nitrogen, in the form of ammonia, can be removed chemically from wastewater by raising the pH to convert the ammonia ion into ammonia gas and stripped from the water by passing large quantities of air through the water. Currently, biological nitrogen removal is popular because it is inexpensive and convenient. Biological nitrogen removal is accomplished by nitrification, converting ammonia to nitrate, accompanied by de-nitrification to reduce nitrate to nitrogen gas.

Removal of phosphorus
Biological phosphorus removal is done by stressing microorganisms to acquire more phosphorus than required for cell growth. Physical processes include dual media filtration to remove low quantities of phosphorus and ultrafiltration or reverse osmosis to remove high quantities of phosphorus. Ten percent of phosphorus is removed by chemical processes, e.g. precipitation using iron and aluminum salts.

Case Study: Green Island Resort in Queensland, Australia

Green Island Resort is Australia's first 5-star ecotourism resort. It is known for its best environmental management especially water and disposal of waste. Implementation of efficient procedures for water management is an important component of the day-to-day management of the resort. The high cost of importing water from 20 kilometres away by barge from the mainland calls for optimum harvesting of rainfall. The architecture of resort buildings is designed to allow direct infiltration of runoff on to the land surface and deep percolation to the underlying aquifer. Grey water from the island's sewerage treatment plant is recycled and reused for toilet flushing, landscape irrigation and as a reserve for fire fighting.

The tertiary treatment sewerage plant has been designed to handle both the resort's effluent and grey water. Sludge residue from the treatment plant is pumped on to a barge each month and transported to the mainland for processing. Liquid effluent from the treatment plant is discharged to the sea through an outfall pipeline with special care taken on the coral environment surrounding Green Island.

Additional information: Green Island Resort at http://www.ozhorizons.com.au/qld/cairns/green/green.htm

5.2 Natural Wastewater Treatment Systems

Systems which use natural features such as soil, vegetation, aquatic flora and fauna for the treatment of wastewater are defined as natural systems. These systems are less costly but require large areas of land not usually available in most tourism facilities.

Several simple alternative treatment methods exist if land is readily available and technical expertise is limited. They include land treatment, subsurface disposal and constructed wetlands. In the natural environment, physical, chemical and biological processes occur when water, soil, plant microorganisms and the atmosphere interact. Natural treatment systems are designed to take advantage of these processes to provide wastewater treatment.

5.2.1 Land-Based Systems

An alternative to advanced wastewater treatment processes, secondary effluent can be applied directly to the ground and polished effluent obtained by natural processes as wastewater flows over vegetation and infiltrates the soil. Land treatment can provide moisture and nutrients for vegetation growth, such as corn or grain for animal feed. It can also recharge/replenish groundwater aquifers. However, large areas of land are required and the feasibility of this treatment may be limited by soil texture and climate. Figure 12 shows three different land-based natural treatment systems: slow rate, overland flow and rapid infiltration (adapted from Metcalf and Eddy (1991) "Wastewater Engineering Treatment, Disposal and Reuse"; McGraw-Hill International Ed., New York).

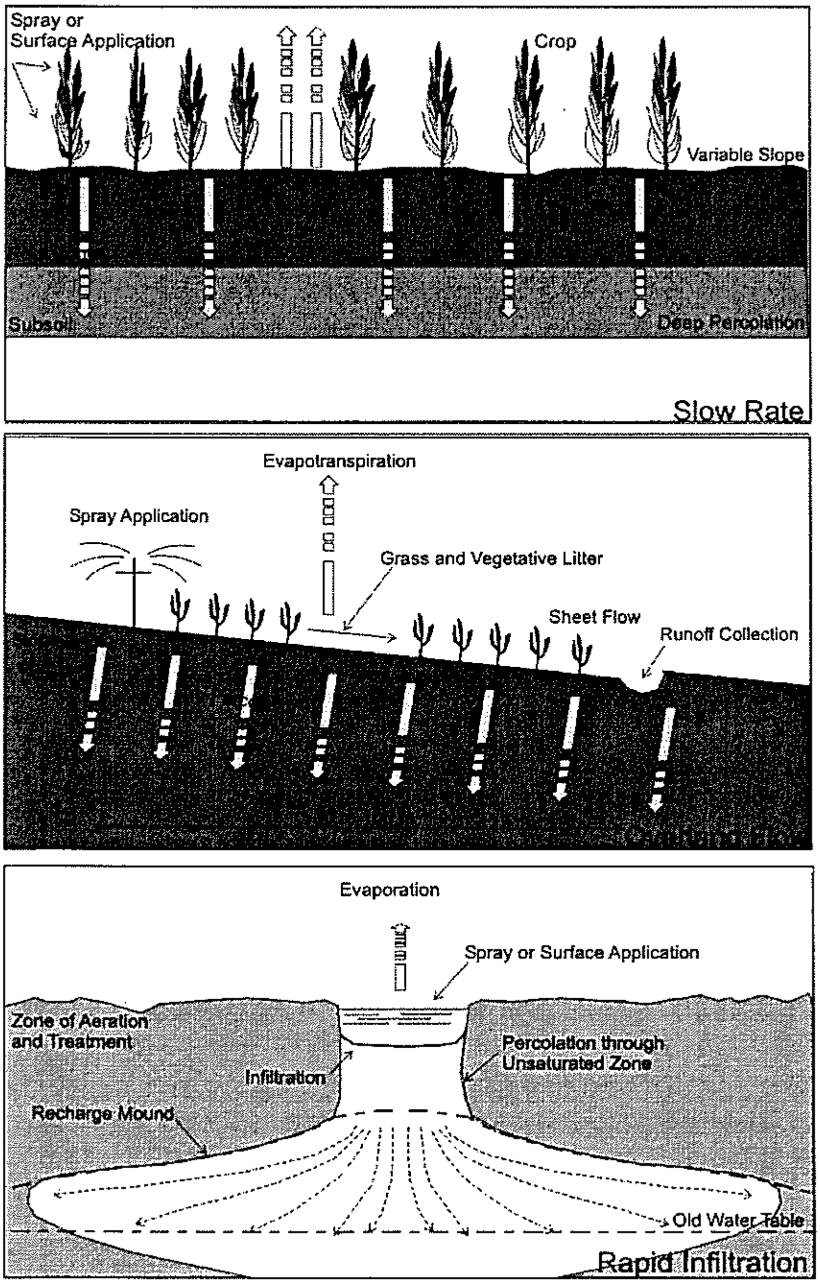

Figure 12: Examples of Land-Based Treatment Systems

5.2.2 Subsurface Disposal Systems

In sparsely populated suburban or rural areas, it is generally not economical to build sewage collection systems and a centrally located treatment plant. Instead, a separate subsurface disposal system can be provided for each facility. This type of treatment system is particularly appropriate in remote areas where tourist facilities (hotels and guesthouses) exist.

A subsurface disposal system consists of a buried field and either a leaching field or seepage pits. A septic tank serves as a settling tank and sludge storage chamber. Although sludge decomposes anaerobically, it eventually accumulates and must be pumped periodically. Floating solids and grease are trapped by a baffle at the tank outlet; settled sewage flows into the leaching field or seepage pits. A leaching field includes several perforated pipelines placed in shallow trenches. The pipes distribute the effluent over a substantial area as it seeps into the soil. If the site is too small for a conventional leaching field, deeper seepage pits may be used instead of shallow trenches. Both leaching fields and seepage pits must be placed above a seasonally high groundwater table.

5.2.3 Wetlands

Wetlands are land areas with water depths typically less than 2ft which support the growth of emergent plants such as cattail, bulrush, reeds and sedges. Vegetation provides a surface for attachment of bacterial films, aids in the filtration and adsorption of wastewater constituents, transfers oxygen into water columns and controls the growth of algae by restricting sunlight penetration.

Constructed wetlands are man-made systems aimed at simulating the treatment process in natural wetlands by cultivating emergent plants on sand, gravel or soil. Constructed wetlands have proven to be a promising treatment option as they require low investment, operation and maintenance costs. The system typically consists of parallel basins with relatively impermeable bottom soils or subsurface barriers, emergent vegetation and shallow water depths of 0.33-2ft. Pretreated wastewater is applied continuously to these systems; treatment occurs when water flows slowly through stems and roots of emergent vegetation.

Other available aquatic systems use floating aquatic plants (water hyacinth and duckweed) and aquaculture (production of fish and other aquatic organisms).

Constructed Wetlands for Wastewater Treatment, Cannon Beach, Oregon, USA

The City of Cannon Beach is a resort community and during the tourist season the population swells from a permanent size of 1,200 to many times that number. Therefore wastewater treatment design would have to be able to accommodate these large fluctuations in wastewater flows, and to meet the water quality standards set by the Oregon Department of Environmental Quality with minimal disturbance to the existing wildlife habitat. Confrontation led to a City commitment to pursue a biological solution instead of more high-tech treatment units to upgrade the treatment system.

The Cannon Beach treatment system consists of a four-celled lagoon complex followed by two wooded wetland cells which serve as a natural effluent polishing system. The fifteen acres of wetlands are primarily red alder, slough sedge and twinberry, including the remnants of an old growth spruce forest. These wetlands act as a natural filter to complete the treatment process, and the wildlife is not disturbed. The system has been a success. Performance of the system has exceeded expectations as the effluent has met its monthly permit requirements. In addition because of this achievement the City received higher funding provided by EPA (Environmental Protection Agency).

Additional information: Office of Water, United States Environmental Protection Agency (EPA) at http://www.epa.gov